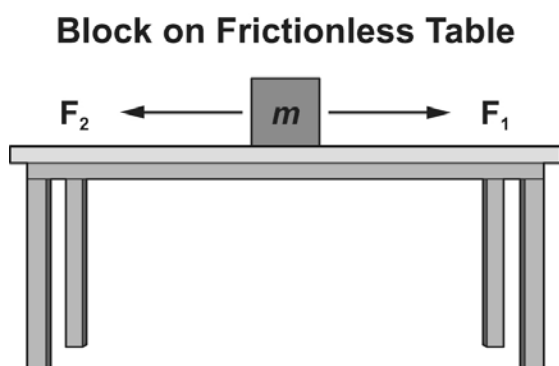


Unit Test: Motion and Forces

Read each question. Circle the letter of the correct answer.

1. Val is running in a park when she sees a dog to her right. Relative to Val, the dog does not appear to be changing position. Which statement explains why the dog appears to not change position?
 - A. The dog is remaining in a stationary position.
 - B. The dog is moving in the opposite direction Val is running.
 - C. The dog is running toward Val at the same speed Val is running.
 - D. The dog is running in the same direction and speed that Val is running.
2. Two slides have identical sizes and shapes but are made from different materials. The same object is allowed to slide down each of the slides. The object accelerates faster down the first slide than the second slide. Which statement is most likely to explain this result?
 - A. Gravity is stronger on the first slide.
 - B. Friction is greater on the second slide.
 - C. The first slide has a greater mass than the second slide.
 - D. The first slide applies more normal force than the second slide.
3. Which statement correctly describes acceleration?
 - A. The acceleration of an object is equal to the mass of the object.
 - B. The acceleration of an object is twice the net force acting on the object.
 - C. The acceleration of an object is half of the net force acting on the object.
 - D. The acceleration of an object is inversely proportional to the mass of the object.
4. Vanita throws a ball across her yard while playing catch. She exerts a force on the ball that ends once it leaves her hand. Which statement describes the motion of the ball in the vertical and horizontal directions just before it is caught? Note: Assume there is no air resistance acting on the ball.
 - A. The ball accelerates in both the horizontal and vertical directions because the gravitational force acts in both directions.
 - B. The ball's motion remains constant in both the horizontal and vertical directions because there are no external forces acting on it.
 - C. The ball accelerates in the vertical direction because of gravitational force, but its motion remains constant in the horizontal direction because no force acts on it in that direction.
 - D. The ball accelerates in the horizontal direction because of gravitational force, but its motion remains constant in the vertical direction because no force acts on it in that direction.
5. A car is driving at a speed of 20 m/s when the driver sees a stop sign up ahead. The driver puts her foot on the brake pedal. Which statement accurately describes the forces acting on a car after the driver hits the brake pedal?
 - A. The forces are unbalanced because the car has a positive speed.
 - B. The forces are balanced because the car is moving at a constant speed.
 - C. The forces are unbalanced because the velocity of the car is decreasing.
 - D. The forces are balanced because the acceleration and velocity of the car are in opposite directions.

6. A team of engineers is attempting to determine the type of material that would be best suited for constructing an aqueduct to deliver water to a drought-stricken region that is prone to seismic activity. Which test will be most helpful to determine the material to use for the aqueduct?
- A. Test materials for their ability to withstand extreme heat.
- B. Test materials for their ability to handle vehicular collisions.
- C. Test materials for their ability to keep water cool for long distances.
- D. Test materials for their ability to withstand physical forces, such as compression, shear, and tension.
7. A box with a mass of m is placed on a frictionless table. Two forces, F_1 and F_2 , act on the block in the directions shown in the diagram. Two trials are performed. Some of the data from each trial are shown in the table.



Trial Data

	F_1 (N)	F_2 (N)	Mass (kg)	Acceleration (m/s^2)
Trial 1	20	10	2	5
Trial 2		10	2	

In Trial 2, F_1 is doubled. Which statement correctly describes the acceleration of the box in Trial 2, compared with Trial 1?

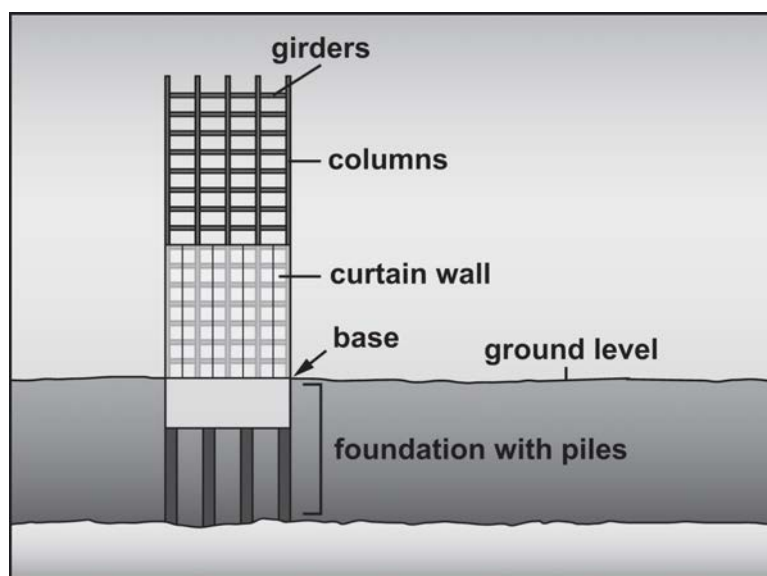
- A. The acceleration is halved.
- B. The acceleration is the same.
- C. The acceleration is twice as great.
- D. The acceleration is three times as great.

8. The table shows mass and weight data of some common items.

Item	Mass on Earth (kg)	Weight on Earth (N)	Mass on the moon (kg)	Weight on the moon (N)
table tennis ball	0.0025	0.024	0.0026	0.0042
golf ball	0.046	0.45	0.046	0.075
billiard ball	0.17	1.7	0.17	0.28
tennis ball	0.057	0.56	0.057	0.093
baseball (major league)	0.14	1.39	0.14	0.23

Based on the data, which conclusion is valid regarding the relationship between the force of gravity, mass, and weight?

- A. Both the mass and the weight of an object depend on the force of gravity.
 - B. Neither the mass nor the weight of an object depends on the force of gravity.
 - C. The weight of an object depends on the force of gravity of the planet, but the mass does not.
 - D. The mass of an object depends on the force of gravity of the planet, but the weight does not.
9. Engineers hope to reduce the overall stress in skyscrapers built in earthquake-prone regions located within the Pacific Ring of Fire.








Which of these methods would effectively reduce the overall stress in these buildings?

- A. Use concrete for the girders because it is resistant to bending.
- B. Build the structures with lighter materials with the same strength.
- C. Reduce cross-sectional area of girders and columns to reduce dead weight.
- D. Create larger buildings with proportionately broader bases to distribute the weight of the structure.

Read each question. Follow the instructions to answer the questions.

10. The images in the table each show an arrow that represents the direction of a different force. Write the letter of the correct force in the box to match each arrow.

- A. gravity
- B. friction
- C. normal
- D. applied
- E. air resistance

11. A car is traveling north on a road at a velocity of 20 m/s. A student considers the relative speeds of the car from different frames of reference. Number the frames of reference in order from 1 to 4 where 1 is the car's fastest relative speed and 4 is the car's slowest relative speed.

_____ riding in the car in the passenger seat
 _____ standing at a corner the car is about to pass
 _____ flying past the car in a helicopter going 80 m/s north
 _____ driving toward the car in another car going 20 m/s south

12. Write one letter in each blank to correctly complete the sentences about rock stress.

1. _____ stress causes faults. It results in one side of rock dropping lower than another.
 2. _____ stress also causes faults. It results in rock being pushed upward. Knowledge of rock stress is important in mining because engineers must 3. _____ to ensure the safety of miners.

1. and 2. A. Compression B. Fault C. Overlap D. Tension	3. I. modify mine designs to manage rock stress J. find ways to decrease natural rock stress in mines K. avoid digging mines deep beneath Earth's surface
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13. Write the letter of each sentence in the table to show whether the sentence describes balanced or unbalanced forces.

Balanced forces	Unbalanced forces

- A.** The vector sum of the forces on an object is zero.
B. The forces on an object cause it to move in a circular motion.
C. The forces on an object cause it to maintain a constant velocity.
D. Two forces of the same magnitude act in the same direction on an object.
E. The forces acting on an object cause the velocity of the object to decrease.
F. The force on an object is equal and opposite to another force acting on the object.

14. A force of 80 newtons is applied to two different objects. It causes Object A to accelerate at 20 m/s^2 , and Object B to accelerate at 40 m/s^2 . Write one letter in each blank to correctly complete the table.

Relationship between Mass and Acceleration

Object	Mass (kg)
A	1.
B	2.
Mass has a(n) 3. relationship with acceleration.	

1. and 2.**A.** 1**B.** 2**C.** 4**D.** 8**3.****I.** direct**J.** indirect

15. Engineers, scientists, and policymakers all play important roles in the development of designs for a fuel-efficient car. Which role in this development is likely to be filled by a scientist, an engineer, or a policymaker? Write the letter of each element in the correct position in the table.

Role of scientists	Role of engineers	Role of policymakers

A. defines the concept of fuel-efficient car**B.** studies the formulation of different types of fuels**C.** tests aerodynamic exterior design to improve fuel efficiency**D.** investigates carbon emissions with respect to different types of fuels**E.** designs an engine part that can use less fuel with the same performance

16. A student collected data to support the relationship described in Newton's second law of motion. She used a 1 kg cart and other masses. She varied the force she pushed the cart with and the mass of the cart. She recorded her data in the table.

Newton's Second Law Experimental Data

Trial	Applied force	Mass of cart (kg)	Acceleration of cart (m/s^2)
1	10	1	10
2	10	2	5
3	30	3	10
4	60	3	20
5	50	5	10
6	60	6	10

Write an X in the correct box in the table to show which pair of trials best supports each claim.

Claim	Trials 1 and 2	Trials 3 and 4	Trials 5 and 6
A. As mass increases, the acceleration decreases given a constant force.			
B. When mass is constant, a change in force results in a change in acceleration.			
C. As mass increases, the force required to keep acceleration constant increases.			
D. With a mass of 3 kg, to achieve an acceleration of 30 m/s^2 , the force must be greater than 30 N.			

17. Engineers at a local sporting goods company are testing the durability of a 0.85 kg baseball bat. In one test they lock the bat in place and launch 0.15 kg baseballs and 0.2 kg softballs at the bat. Each ball hits the bat with a force of 15,000 N. Write the letters of the words or phrases from the list to correctly complete the paragraphs about the forces and motion of the two balls.

The contact with the bat causes the baseball to initially slow down due to a force of **1.** _____

applied to the baseball by the bat. The direction of this force is **2.** _____ the direction of the force the ball applies to the bat.

The magnitude of the acceleration of the softball due to the force of the bat is **3.** _____ times the magnitude of the acceleration of the baseball due to the force of the bat.

This comparison is true because the force that slows the softball down when it hits the bat has

4. _____ the force that causes the baseball to initially slow down. When the net force acting on an object is held constant, objects with larger masses experience **5.** _____ acceleration.

1. A. 2,250 N B. 12,750 N C. 15,000 N D. 00,000 N	2. E. opposite to F. the same as G. perpendicular to	3. H. 1/2 I. 2/3 J. 3/4 K. 1 L. 2	4. M. a smaller magnitude than N. the same magnitude as O. a larger magnitude than	5. P. less Q. equal R. greater
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Read each statement. Write your answer on the lines.

18. During practice, two baseball players hit line drives that both have the same initial angle relative to the ground. Each ball has the same mass, but Batter A hit the ball with twice as much force as Batter B.

Explain how Newton's second law of motion can be used to compare the motion of the balls while they are in contact with the bat.

Explain the difference between the horizontal and vertical components of the acceleration of the balls once they are in flight.

- 19.** Two students are pushing and pulling a 0.75 kg sled around a section of flat, hard and smooth snow. Each student applies a 1.5 N force to the sled. The students either both push the sled to the left, both push the sled to the right, or one pulls the sled to the left while the other student pulls the sled to the right. A third student calculates that the magnitude of the accelerations for one of these scenarios is 0 m/s² and 4 m/s² for the remaining two scenarios.

Use the data to support which scenario is an example of balanced forces acting on an object and which is an example of unbalanced forces acting on an object.

Use the data to support a mathematical relationship between the forces acting on an object, the mass of the object, and the acceleration of the object.

- 20.** A structural engineer is designing a deck to place on the back of a newly constructed home in northern Vermont. Think about her design process for the deck.

Describe two different loads the deck must support.

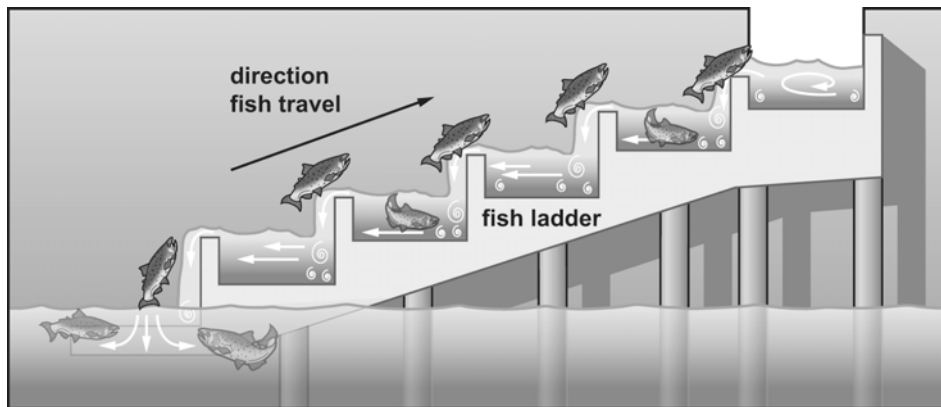
Identify two design criteria the engineer might have to consider to build the deck.

Explain a tradeoff a designer might have to make when building the deck.

Directions: Read the passage, then answer the questions that follow.

Fish Ladders and Migrating Fish

Many species of fish, including salmon and sturgeon, swim hundreds of miles upstream to spawn each spring. On their way, they come across some natural and human-made barriers such as waterfalls and dams. Fish passages, or fish ladders, are often built next to dams to help the fish swim upward and cross the dam. Designing, building, and maintaining fish ladders are essential for preserving fish populations in these waterways. A group of engineers is designing a fish ladder to be built alongside a local dam. The fish must climb 120 ft vertically in order to cross the dam. The ladder must have a gradual slope to help the fish climb more easily and maintain their energy so that they can move up the entire ladder. If the water is not falling too fast, the fish can swim up through the water to move up the ladder. A simple model of a fish ladder is shown.



There are several different kinds of fish ladders, including pool and weir, vertical channel, roughened passage, and hybrid designs. For any given kind of fish ladder, there are many parameters that will vary from one design to another, such as pool volume, height differential between pools, water depth, and slope. The group of engineers is deciding between four different designs for the ladder. They decide that four criteria should be considered in selecting the final design: cost, durability, how attractive the design is to fish, and how much the design controls water flow. The group has created the decision matrix shown to evaluate four types of material available for building the fish ladder. The higher the score in the matrix for a criterion, the more desirable it is for the design.

Fish Ladder Design Decision Matrix

Criteria	Design 1	Design 2	Design 3	Design 4
Durability	2	2	4	5
Cost	2	4	1	2
Attractive to fish	1	4	3	3
Control water flow	3	2	5	1
Total points	8	12	13	11

21. The engineers are designing a base for the pools in the ladder. The base is a square with edge lengths of 1.5 meters. A criterion for the base is that it must withstand a stress of $3,200 \text{ N/m}^2$. In tests, a prototype of the base withstood a total force of $4,500 \text{ N}$ before it failed. Which statement describes whether the prototype met the criterion for resisting stress? Circle the letter of the correct answer.

A. No, because it was only able to withstand a stress of $2,000 \text{ N/m}^2$.
B. No, because it was only able to withstand a stress of $3,000 \text{ N/m}^2$.
C. Yes, because it was able to withstand a stress of $6,750 \text{ N/m}^2$.
D. Yes, because it was able to withstand a stress of $10,125 \text{ N/m}^2$.

22. Write an X in the correct box in the table to show whether each statement describes a criterion or a constraint.

Statement	Criterion	Constraint
A. The ladder will reduce the amount of energy fish must use.		
B. The cost of materials for the ladder must remain under \$400,000.		
C. Construction on the ladder must be completed in less than nine months.		
D. The ladder should resemble the natural environment of the fish as much as possible.		

23. Using the decision matrix, circle the letters of all the statements that describe valid comparisons between materials.

A. Design 3 is more durable than Designs 1 and 2.
B. Design 2 is superior to Design 1 in both costs and durability.
C. Design 4 better meets the criteria than both Design 1 and Design 2.
D. Design 3 is the design that best meets the criteria for the fish ladder.
E. Design 4 is the most durable design but is least able to control water flow.

24. In rivers where large numbers of fish need to be accommodated, a fish lift is used instead of a fish ladder. A fish lift transports a chamber of water filled with fish from the downstream side of the river up and over the dam. From an engineering perspective, the fish lift functions similarly to an elevator. The criteria engineers consider when building a fish lift are durability, cost of materials, stability of the lift, and reduction of stress on the fish as they travel up over the dam. Note: the fish are neutrally buoyant in the water. Write your answers on the lines.

Identify the load on the fish lift while it waits at the bottom of the riverbed waiting for fish to accumulate inside.

Analyze the forces impacting the fish lift, and explain which criterion should be prioritized to prevent the fish lift from collapse, using at least two forces in your explanation.

Describe at least one way the engineers can reduce the stress on the fish lift while it is moving upward.

25. One design uses both metal cables and a cement column to help the ladder resist stresses. The engineers are trying to determine whether steel or aluminum alloy cables would be best. Steel is stronger than aluminum alloy, but steel reacts more harshly with water and oxygen. Aluminum alloy is lighter, almost as strong as steel, and slightly more expensive than steel.

Describe how cables and columns can be used to help the ladder resist different stresses.

Analyze the criteria for the cable used in construction of a fish ladder, and identify one additional criterion for its use. Explain why this new criterion would be needed.

Compare the criteria and constraints of the cables, and identify one advantage and one disadvantage of using the aluminum alloy cable in the design. Explain why each is an advantage or disadvantage.
